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The presence of water-soluble cations and anions in the martian regolith has been the subject of speculation for some time (e.g. Malin, 1974). Viking lander data provided evidence for salt-cemented crusts on the martian surface. This evidence is in the form of lander imagery of friable soil layers and planar fragments of disturbed soil (e.g. Moore *et al.*, 1977; Mutch *et al.*, 1977), and the detection of abundant sulfur and some evidence for chlorine in the soil (e.g. Clark *et al.*, 1976). Martian sulfur is very likely to exist in the form of sulfate, and chlorine in the form of chlorides (Clark *et al.*, 1976), chlorates, or perchlorates (Oyama *et al.*, 1977). Following the Viking landings, there was considerable discussion of other salt-forming materials which "should" exist on the martian surface, including carbonates (e.g. Gooding, 1978) and nitrates (e.g. Yung *et al.*, 1977; Yung, 1989). Very recently, earth-based IR spectroscopic evidence has been obtained indicating the presence of carbonates as well as sulfates and other hydrates on the martian surface (Pollack *et al.*, 1989). Carbonates have been detected in the SNC meteorites that are commonly believed to have a martian origin (Gooding *et al.*, 1988). If the crusts observed at the two Viking landing sites are, in fact, cemented by salts, and these crusts are globally widespread, as IRTM-derived thermal inertia studies of the martian surface seem to suggest (e.g. Jakosky and Christensen, 1986), then evaporite deposits, probably at least in part derived from brines, are a major component of the martian regolith. The composition of liquid brines in the subsurface, which not only may be major agents of physical weathering (Malin, 1974), but may also presently constitute a major deep subsurface liquid reservoir (Clifford, 1987), is currently unconstrained by experimental work.

A knowledge of the chemical identity and rate of production of martian brines is a critical first-order step toward understanding the nature of both these fluids and their precipitated evaporites. Laboratory experiments are being conducted to determine the identity and production rate of water-soluble ions that form in initially pure liquid water in contact with Mars-mixture gases and unaltered Mars-analog minerals. The main components of the experiment apparatus consist of ten identical, hermetically sealable sample containers made of Teflon. The interior volume of the containers is 250 ml. The lids of each container have two ports to which are fixed stopcocks to provide gas flow access to the head space when needed. Above one of the stopcocks a stainless steel vacuum/gas line fitting was mounted. Eight of the containers will be kept within a large (and heavy) bell jar. The bell jar's mouth is sealed to its base plate with vacuum grease. The bell jar base contains two gas ports. Each port has a stainless steel gas line running from the exterior of the base. One line is attached to a cylinder of gas with the same mixture as that of the martian atmosphere. The entire assembly of bell jar and enclosed sample containers set within a large refrigerator whose interior can be maintained at $20 \pm 0.5^\circ\text{C}$. The other two sample containers also reside within the refrigerator.

The experiment pilot run set consists of ten samples. Individual pristine minerals to be used to simulate martian rocks were chosen on the basis of SNC meteorite mineralogy as outlined by McSween (1985). Six of the samples are composed of 50 g of sorted and mixed minerals (57.2% augite, 25.26% forsterite, 13.14% anorthoclase, 3.14% ilmenite, 0.78% pyrite, and 0.48% chloro-apatite) acting as unaltered Mars rock analogs immersed in 100 ml of de-oxygenated, doubly distilled liquid H_2O , and above which the head space is filled with a martian gas mixture (CO_2 95.50%, N_2 2.70%, Ar 1.60%, O_2 0.13%, CO 0.07%). These six containers will be the source of the principle data to be obtained by this pilot run set. Two other sample containers are filled with the same materials as those just discussed but with terrestrial gas in their head space. The results of the analysis of their fluids will provide some ability to compare the "martian" verses terrestrial environmental influence, which in this case is only the difference between the two

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atmospheric compositions. Two other sample containers hold 100 ml of de-oxygenated, doubly-distilled H₂O and martian gas mixture in the head space (no rock particles). These serve as controls. The rock/gas/water or gas/water mixtures are allowed to interact with one another for specific time durations then the reaction are stopped by the removal of the fluid, which is stored under argon in the transfer containers. The individual run durations were chosen on the basis that most chemical reaction rates (including those that are grain-rind diffusion limited) decay exponentially with time.

Eight Mars gas-containing containers were placed within a bell jar. The bell jar is flushed with Mars gas. The bell jar and the two containers with Earth gas in their head space reside within a refrigerator. The temperature within the refrigerator is maintained at a constant $20 \pm 0.5^\circ \text{C}$. The temperature is periodically monitored with an analog (Hg-containing) thermometer which sets within a depression on the bell jar base (exterior to the bell jar). The gas pressure within the sample containers is 1 bar. When sample interaction is terminated, the container is removed from the bell jar. The fluids of the samples are analyzed for their pH and for a number of cations and anions. The cations to be searched for are Fe, Mg, Al, K, Na, Ca, Ti, Mn, and Ba with minimum quantity detection limit of 1 ppm. The anions to be examined are Cl⁻, F⁻, SO₄⁼, SO₃⁻, NO₃⁼, NO₂⁻, and CO₃⁼ with minimum detection limits of 10 ppm. **The preliminary results at the end of the sixth month of the experiment are that "martian" aqueous chemistry is dominated by Ca and CO₃, and a CO₂ atmosphere significantly alters dissolution rates and products (in comparison to the terrestrial case).**

The results of the pilot run set will provide the first experimental determination of the rates of formation and relative abundances of the common water-soluble cations and anions that form in liquid water in contact with initially unaltered "martian" rocks and the gases of the present martian atmosphere for up to two years after initial contact. If an equilibrium composition is recognized or can be extrapolated from trends in the production rates, then a model martian brine composition will be established. Such a brine can then be synthesized in any lab. The dehydration of the model brine could be used to create a model martian evaporite. The presence of brines on Mars has been hypothesized, both as a crustal store of H₂O-rich liquid and as an agent of chemical rock weathering. The physical properties of martian brine can be evaluated by making solutions of brine at various concentrations, guided by the results of this experiment, and then measuring such parameters as density and freezing point. The model martian brine can also be used in rock weathering experiments or calculations. An extension of this work would be to investigate the effect of brine/evaporite composition on clay mineral chemistry. The spectral signature of the model evaporite can be compared with spectral data to be obtained from past, present, or forthcoming missions and observations.

REFERENCES

- Clark, B.C., *et al.* (1976) Inorganic analyses of martian surface samples at the Viking landing sites, *Science*, **194**, 1283-1288. Clifford, S.M. (1987) Polar basal melting on Mars, *J. Geophys. Res.*, **92**, 9135-9152. Gooding, J.L. (1978) Chemical weathering on Mars: Thermodynamic stabilities of primary minerals (and their alteration products) from mafic igneous rocks, *Icarus*, **33**, 483-513. Gooding, *et al.* (1988) Calcium carbonate and sulfate of possible extraterrestrial origin in the EETA79001 meteorite, *Geochim. Cosmochim. Acta*, **52**, 909-915. Jakosky, B.M. and P.R. Christensen (1986) Global duricrust on Mars: Analysis of remote sensing data, *J. Geophys. Res.*, **91**, 3547-3559. Malin, M.C. (1974) Salt weathering on Mars, *J. Geophys. Res.*, **79**, 3888-3894. Moore, *et al.* (1977) Surface materials of the Viking landing sites, Mars, *J. Geophys. Res.*, **82**, 4497-4523. Mutch, T.A., *et al.* (1977) The geology of the Viking 2 site, *J. Geophys. Res.*, **82**, 4452-4467. Oyama, *et al.* (1977) Preliminary findings of the Viking gas exchange experiment and a model for martian surface chemistry, *Nature*, **265**, 110-114. Pollack, *et al.* (1989) Thermal emission spectra of Mars (5.4-10.5 mm): Evidence for sulfates, carbonates, and hydrates (abs.), *Bull. Amer. Astron. Soc.*, **21**, 956-957. Siever, R. and N. Woodford (1979) Dissolution kinetics and the weathering of mafic minerals, *Geochim. Cosmochim. Acta*, **43**, 717-724. Yung, Y.L., *et al.* (1977) Photochemistry of nitrogen in the martian atmosphere, *Icarus*, **30**, 26-41. Yung, Y.L. (1989) Is the martian atmosphere denitrified by ice clouds? (abs.), *Bull. Amer. Astron. Soc.*, **21**, 979.